every plant." The book before us is written in twenty-three chapters, devoted to such topics as Plant Worship, Plants in Witchcraft, Plants in Fairy-Lore, Love-Charms, Dream-Plants, Plant Language, Plants and their Legendery History, etc., etc. A few titles have a faint botanical color, as: Plants and the Weather, Plant Names, and Plants in Folk-Medicine, but it is very faint, indeed. Under the first, which certainly admits of at least a semi-scientific treatment, we have such rhymes as

"Sow peas and beans in the wane of the moon.
Who soweth them earlier, he soweth too soon.
That they with the plant may rest and rise,
And flourish with bearing, most plentiful wise."

And

"Many haws
Many snaws."

And again:

"When the aspen leaves are no bigger than our nail,
Is the time to look out for truff and peel."

In the chapter on plant names the treatment is better, but in that on Folk-Medicine we drop into poetry again, *e. g.*:

"Eat an apple going to bed,
Make the doctor beg his bread."

And

"The fair maid who, the first of May,
Goes to the fields at break of day,
And washes in dew from the hawthorn tree.
Will ever after handsome be."

Now, although this is not a botanical book, and while to a botanist many of its pages seem trash, yet for those for whom it was written the work is well done, and will be welcomed by many a reader.—*Charles E. Bessey.*

GEOLOGY AND PALÆONTOLOGY.

MARSH ON CRETACEOUS MAMMALIA.[1]—Professor O. C. Marsh has been successful in obtaining the teeth and bones of a number of species additional to the *Meniscoëssus conquistus* Cope, discovered by Wortman in 1882. The remains described have been found separate and fragmentary, and they indicate several species of small size belonging to the Multituberculata

[1] Discovery of Cretaceous Mammalia. By O. C. Marsh. *Amer. Journal Sci. Arts*, July and August Nos., 1889, pp. 81-177.

and to the Bunotheria. The former are typical members of the order, while though it is at yet difficult to locate the latter with certainty, they display no dental characters not found in the Creodonta. No Condylarthra have been as yet obtained, a fact which so far indicates the distinction between the faunæ of the Laramie and Puerco epochs. Apart from this, the fossils strongly resemble those of the Puerco, and detract nothing from the supposition which I have entertained that the latter fauna belongs to the Mesozoic series. It is needless to say that the position which I assumed in 1869, that the Laramie belongs to the Cretaceous system, and is not Cænozoic, is fully sustained.

The manner in which Professor Marsh has done this work requires notice. The most superficial knowledge of the subject would have shown him that the molar teeth which he has described as representing distinct genera belong mostly to different parts of the series of the same genus, and often species, and not unlikely, individuals. Thus, supposing superior anterior molars to be regarded as typical, we have the posterior and inferior molars, and even the premolars of the same genus described under separate generic names. In his first contribution nine generic names may be, with the greatest probability, referred to two genera. One of these is the genus Meniscoëssus, known since 1882, and the other is not shown to be distinct from Chirox or Polymastodon of the Puerco fauna. Of Bunotheria the three genera are proposed on teeth from different positions in the jaws of forms which may well belong to one genus, and no evidence is brought forward to show how they differ generically from the smaller species of Sarcothraustes of the Puerco. This is not the way to advance science.

Professor Marsh states that the genus Meniscoëssus was described from a tooth which he supposes to belong to a reptile. The fact is that was founded on the molar tooth of the mammal to which Professor Marsh now gives, among others, the name Selenacodon. (See AMERICAN NATURALIST, 1882, p. 830.)—*E. D. Cope.*

NOTES ON THE ORIGIN AND HISTORY OF THE GREAT LAKES OF NORTH AMERICA.[1]—*Discovery of the ancient course of the St. Lawrence River.* Previous investigations by the author showed that there was a former river draining the Erie basin and flowing into the extreme western end of Lake On-

[1] Abstract from the Proceedings of the American Association for the Advancement of Science, vol. xxxvii.

tario, and thence to the east of Oswego, but no further traceable, as the lake bottom rose to the northeast. Upon the southern side there was a series of escarpments (some now submerged), with vertical cliffs facing the old channel. By recent studies of the elevated beaches, it is demonstrated that the disappearance of this valley is due to subsequent warpings of the earth's crust, and that the valley of the St. Lawrence was one with that of Lake Ontario. Recent discoveries of a deep channel upon the northern side of Lake Ontario (a few miles east of Toronto); and of the absence of rocks to a great depth under the drift, far beneath the surface of Lake Huron, between Lake Ontario and the Georgian Bay—and in front of the Niagara escarpment, between these lakes—of a channel in Georgia Bay, at the foot of the escarpment, and of the channel across Lake Huron, also at the foot of a high submerged escarpment, show that the ancient St. Lawrence, during a period of high continental elevation, rose in Lake Michigan, flowed across Lake Huron, and down Georgian Bay and a channel, now filled with drift, to Lake Ontario ; thence by the present St. Lawrence valley to the sea, receiving on its way the ancient drainage of the Erie basin and other valleys.

Origin of the basins of the Great Lakes. The two questions involved are the "origin of the valleys" and the "cause of their being closed into water basins." The basins of Lakes Ontario and Huron are taken for consideration. The previous paper, upon the course of the ancient St. Lawrence, shows that the Huron and Ontario basins are sections of the former great St. Lawrence valley, which was bounded, especially upon the southern side, by high and precipitous escarpments, some of which are submerged. Upon its northern side there were lesser vertical escarpments, now submerged, with walls facing the old valley. The valley was excavated when the continent was at a high altitude, for the eastern portion stood at least 1,200 feet higher than at present, as shown by the channels in the Lower St. Lawrence, in Hudson's Straits, and off the New York and Chesapeake Bays. The valley was obstructed in part by drift and in part by a north and northeastward differential elevation of the earth's surface, due to terrestrial movements. The measurable amount of warping defied investigation until recently, but it is now measured by the uplift of the beaches and sea cliffs. Only one other explanation of the origin of the basins need be considered—that of the "Erosion by Glaciers," (*a*) because the lake basins occur in glaciated regions ; (*b*) glaciers are considered (by some) to erode ; (*c*) supposed necessity, as the terrestrial warping was not known.

In reply: Living glaciers abrade but do not erode hard rocks, and both modern and extinct glaciers are known to have flowed over even loose moraines and gravels. Again, even although glaciers were capable of great plowing action, they did not affect the lake valleys, as the glaciation of the surface rocks shows the movement to have been at angles (from 15° to 90°) to the trend of the vertical escarpments against which the movement occurred. Also, the vertical faces of the escarpments are not smoothed off, as are the faces of the Alpine valleys down which the glaciers have passed. Lastly, the warping of the earth's surface in the lake region since the beach episode, after the deposit of the drift proper, is nearly enough to account for all rocky barriers which obstruct the old valley and form lake basins.

Establishment and dismemberment of Lake Warren. This is the first chapter in the history of the Great Lakes, and is subsequent to the deposit of the upper boulder clay, and therefore the lakes are all very new in point of geological time. By the warping movements of the earth's crust, as shown in the beaches—after the deposit of the later boulder clay—the lake region was reduced to sea level, and there were no Canadian highlands northward of the Great Lakes. During the subsequent elevations of the continent beaches were made around the rising islands. Thus, between Lakes Erie, Huron and Ontario a true beach was formed at 1,690 feet above the sea around a small island rising 30 feet higher. With the rising of the continent, Lake (or perhaps Gulf of) Warren—a name given to the sheet of water covering the basin of all the Great Lakes—was formed. A succession of beaches of this lake have been worked out in Canada, and from Lake Michigan to New York, extending over many hundreds—almost thousands—of miles. Everywhere the differential uplift has increased from almost zero, about the western end of the Erie basin, to three, five, and, in the higher beaches, more feet per mile. With the successive elevations of the land this lake became dismembered, as described in the succeeding papers, and the present lakes had their birth. The idea that these beaches in Ohio and Michigan were held in by glacial dams to the northward is disproven by the occurrence of open water and beaches to the north, which belong to the same series, and by the fact that outlets existed where glacial dams would be required.

Discovery of the outlet of Huron-Michigan-Superior Lake into Lake Ontario, by the Trent Valley. With the continental elevation described in the last paper—owing to the land rising more rapidly to the northeast—Lake Warren became

dismembered, and Huron, Michigan and Superior formed one lake ; the Erie basin was lifted out of the bed of Lake Warren and became drained, and Ontario remained a lake at a lower level. The outlet of the upper lake was southeast of Georgian Bay by way of the Trent valley into Lake Ontario, at about sixty miles west of the present outlet of this lake. The outlet of this upper lake was 26 feet deep where it connected with the Trent valley, and the channel was from one to two miles wide. This, for a few miles, is cut across a drift ridge to a depth of 500 feet. With the continued continental uplift to the northeast (which has raised the old beach at the outlet into the Trent valley, about 300 feet above the present surface of Lake Huron), the waters were backed southward and overflowed into the Erie basin, thus making the Erie outlet of the upper lakes to be of recent date. This is proven by the fact that the beach which marked the old surface plain of the upper Great Lake descends to the present water level at the southern end of Lake Huron.

Erie the youngest of all the Great Lakes. The Erie basin is very shallow, and upon the dismemberment of Lake Warren was drained by the newly constructed Niagara River (except, perhaps, a small lakelet southeast of Long Point). Subsequently the northeastward warping (very much less in amount than farther northward at the Trent outlet) eventually lifted up a rocky barrier and formed Erie into a lake in recent times, thus making Erie the youngest of all the lakes. The beaches about Cleveland are not those of separated Lake Erie, but belong to the older and original Lake Warren.

[NOTE.—To distinguish from the modern, the ancient valley of the St. Lawrence, above described, is named the "Laurentian," the ancient river from the Erie basin the Erigan, the Huron-Michigan-Superior Lake the Algonquin, as also the beach which marked its shores and the river which discharged its waters by the Trent valley. The expanded, but separate, Lake Ontario is named the Iroquois, as also its principal beach, now at 116 feet above its modern surface at the extreme western end of the lake, while at about 135 miles northeastward (near Trenton) its elevation is 435 feet.—*J. W. Spencer*, University of Georgia, Athens, Ga.]

KRAKATOA.—A period of five years has not been found too long in which to collect and collate the material necessary for a history of the gigantic eruption of 1883, which has been

made the subject of elaborate Reports by Dutch, German and English investigators.[1]

These Reports have been recently published and have been ably reviewed in recent issues of the *Contemporary* and *Edinburgh Reviews*.[2]

For a description of the physical characteristics of the great eruption the reader may consult these publications, but the scientific results as detailed in the several Reports may be briefly summarized. The process by which the eruption was brought about is considered to be typical of the physical action of volcanoes all over the world. Sea and surface water obtain access to the vent or to the heated rocks below it, and if brought suddenly into contact may give rise, by the development of steam, to earthquakes or eruptions of moderate strength, but it is to the slow percolation of water into rocks in a certain condition that the author of the English Report attributes the principal part in cataclysmal outbreaks. The water combines with the material of the rock, and by this combination the melting point of the rock is reduced; it only requires the subjection of the hydrated compound to such heat as would be supplied by the anhydrous lavas in a fluid condition to disengage steam and other gases in enormous quanities, and to produce outbursts proportionate to the pressure and the strength of the inclosing walls. If, while this process is going on; water in large quanities gains access to the surface of the heated mass, solidification might take place and the escape of gases through the crater would be temporarily checked. When at last the accumulated force bursts the newly-formed crust, this and other obstacles would be speedily removed by the tremendous violence of the blast, and the sides of the crater might either be blown away or fall into the seething lava. Such appears to have been the working of the final eruption of Krakatoa. The objection that water could not percolate to great depths, owing to the upward pressure of steam, already

[1] Krakatau. Par. M. Berbeck. Publié par ordre de Son Excellence le Gouverneur Général des Indes Néderlandaises. Batavia: 1884 and 1885. Paris; 1885 and 1886.

The Eruption of Krakatoa and Subsequent Phenomena. Report of a Committee appointed by the Royal Society 1888.

Untersuchungen über Dammerungserscheinungen zur Erklärung der nach dem Krakatau-Ausbruch beobachteten atmosphärisch-optischen Störung. Von J. Kiessling. Hamburg and Leipzig: 1888.

[2] *Contemporary Review*, November, 1888. New York; Leonard Scott Publishing Company.

Edinburgh Review, January, 1889. New York; Leonard Scott Publishing Co.

formed, is met by recent experiments which show that the capillary action continues in spite of such pressure.

The presence of volcanic cones and craters on the moon would seem to invalidate the "steam engine" theory as well as the hydrated lava theory of Professor Judd, unless the presence of water in large bodies is admitted, On both the earth and moon the expansion of fluid rock in the process of cooling would bring to bear an enormous pressure, resulting in outwellings of lava, and violent eruptions would be accounted for by the development of steam on a large scale. It is generally admitted that communication exists not unfrequently between reservoirs of molten rock at great distances from each other on lines of fissure. Heated rocks, subjected to the hydration and aeration of infiltrated water would probably occupy more space in a solid than in a pasty or liquid condition, and would melt at a lower temperature. Contraction by cooling of the solidified part of the globe, works in the opposite direction; but while this process is fairly regular and even, solidification may take place unequally, rapidly, and by local causes, such as cooling by extensive aqueous percolation. Other causes of periodic increases of pressure would be the shrinkage of the earth's crust upon the cooling interior, the percolation of water through fissures and the closure of these fissures by changes of level, so that steam developed at some miles below the surface would force the fluid lava through the nearest volcanic vent. As far as the argument from the moon is concerned, it can be readily disposed of by admitting the previous existence of water on its surface, which has been entirely absorbed by the rocky substance.

Among the attendant phenomena of the eruptions were the sea-waves. These caused greater destruction both to property and to human life than any other of the attendant phenomena. They are treated at great length by Captain Wharton in the English Report. Undulations were produced reaching as far as Havre, a distance of 10,780 miles from the original source of disturbance. The seismic flows and ebbs which thus covered a very large part of the globe were composed of long undulations, with periods of over an hour, and of shorter superposed irregular waves at brief intervals. The rate of propagation was in all cases less than theory would demand for the supposed depth of water. The average speed seems to have been something between 330 and 380 miles per hour. The mean depths deduced by the usual formula from this speed are less than those given by actual soundings. The cause of this discrepancy

is not clear; but if the tide gauges can be relied upon, and the disturbances recorded are due to identical original waves, it seems probable that submarine elevations and ridges, hitherto unknown, retard the progress of the disturbance. The period of the long wave was originally about two hours, but at distant stations, such as Orange Bay and the ports of the English Channel, the period seems to have been reduced to about one fourth, and, throughout the course of the undulations, its original character appears to have undergone considerable modification. The cause of an undulation with a period of two hours remains a mystery, but of the correspondence between the water and air waves in point of time at starting there can be no question. An upheaval of the sea bottom must have been very slow to account for the length of the wave; no earthquake was observed, and the evidence generally is against earth disturbance as a cause. It is noted that the bulk of the fragments thrown out during the explosions must have fallen into the sea, and by their impact, almost coinciding with the violent evisceration of the crater, must have contributed to the rush of the destructive waves, and Captain Wharton calculates that a fiftieth part of the missing mass of Krakatoa, which was estimated to be at least 200,000,000,000 cubic feet, would, by dropping suddenly into the water, form a wave circle of 100 miles in circumference, 20 feet high, and 350 feet wide. But this is inadequate to account for the long wave; and he therefore holds that the destructive waves in the Strait of Sunda were mainly due to masses falling into the sea, or to sudden explosions under the sea, but that the long wave recorded by distant tide guages had its origin in upheaval of the bottom.

Another marked accompaniment of the explosion was the air wave. Reports from 47 stations representing the entire civilized world show that an air wave spread out from Krakatoa as a centre expanding in a circular form till half round the globe, concentrated again towards the Antipodes, whence it started afresh and travelled back to Krakatoa, occupying in the double journey 36 hours, rebounded and set off again on the same revolution, and repeated the movement at least three times sufficiently strongly to be recorded. Seven passages, going and returning were indicated by the diagrams at some stations. The whole process was almost exactly similar to the alternate expansions and contractions of a wave of water caused by dropping a stone at the centre of a circular pool. The barograms give tidings of atmospheric movements comparable to gigantic waves of sound, starting from a small area

and encompassing the globe, several times in succession, completing each circuit in about 36 hours. The mean speed of propagation was about 700 miles an hour, less by 23 miles than the velocity of sound at zero Fahrenheit; the velocity, in fact, seems to have corresponded to that of sound in air at 20 or 30 degrees below zero.

Among other interesting observations noted in connection with this eruption are those relating to the propagation of sound. Authentic instances are recorded of sounds caused by the explosions being heard at distances of 1210, 1902, 2014, 2267, and 2968 miles, being quite the longest distances that sound has been known to travel. The English Report includes a number of interesting and instructive hypotheses. The concensus of opinion as to the red sunsets which formed so conspicuous a feature of the autumn evenings of 1883 is that they may be traced to Krakatoa. The general conclusions are admirably traced by Sir Robert Ball:

First of all it would be natural to ask whether the existence of volcanic dust in the air could have produced the optical effects that have been observed. This must be answered in the affirmative. Then it would be proper to inquire whether other volcanic outbreaks in other parts of the world, and on other occasions, had been known to have been followed by similar results. Here, again, we have page after page of carefully stated and striking facts which answer this question also in the affirmative. Next it would be right to see whether the sequence in which the phenomena were produced at different places in the autumn of 1883, tallied with the supposition that they all diverged from Krakatoa. The instances that could be produced in support of the affirmative number many hundreds, though it must be admitted that there are some few cases about which there are difficulties. Surely we have here what is practically a demonstration. It is certain that these optical phenomena existed. No cause can be assigned for them except the presence, at that particular time, of vast volumes of dust in the air. What brought that dust into the air except the explosion of Krakatoa? Most people find themselves unable to share the scruples of those who think there can be a doubt on the matter. Would another eruption of Krakatoa, followed by a repitition of all the optical phenomena, convince them that in this case, at all events, *post hoc* was *propter hoc*. Perhaps not, if they have already failed in being convinced by the fact that, when Krakatoa exploded two centuries ago, blood red skies appear to have been seen shortly afterwards as far away as Denmark.